



# Spherical Primary Optical Telescope (SPOT) Segment Fabrication

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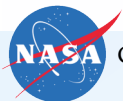
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**Scott Smith, Code 551**

**Matt Balcors, Code 551**

**Carl Strojny, Code 551**



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# SPOT - 10x Cheaper Telescopes

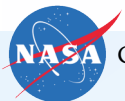
- **SPOT Architecture Simplifies Large Segmented Telescopes**
  - Spheres are easier to make and test
  - Fewer degrees of freedom to control
- **Real time WFSC with on-board star**
  - Enables operation in more challenging environments (ISS)
  - Allows use of less exotic mirror materials
- **SPOT mirror design enables real time ROC control**
  - Mirror is cast with shape that decreases WFE induced by ROC change by 10 X
  - Casting of mirror decreases cost of segment blanks 15 X
- **Spherical Primary Telescopes have decreased FOV**
  - SPOT is best utilized for:
  - Planetary camera, LIDAR, Laser Comm





# SPOT Testbed Status

- 3 hexagonal mirror blanks (35" point to point) have been cast
- Segment 1 was figured at GSFC completed at QED using magnetorheological finishing (MRF)
- New GSFC figuring facility brought on-line to complete initial figuring on segments 2 and 3
  - New machine can handle segments as large as 1 meter
- Segment 2 is in final figuring at QED
- Segment 3 is in figuring at GSFC
- Mirror tip/tilt piston and ROC control assemblies complete and software for control is being developed
- Test Bed should be operational this winter in Bld 7
- Modification of SPOT hardware for flight is evolutionary rather than revolutionary





# SPOT Design Concepts

Phase Retrieval Camera & Point Source

Secondary Mirror

Quaternary Mirror

Tertiary Mirror

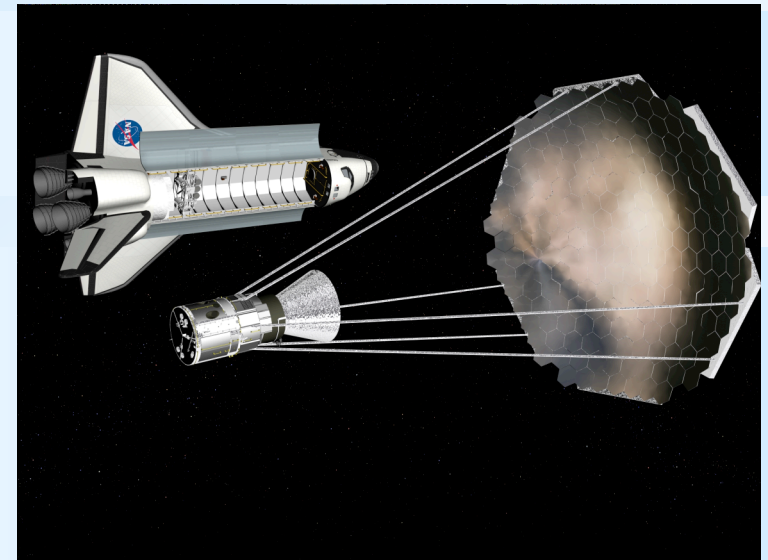
Instrument Camera

Segmented Primary

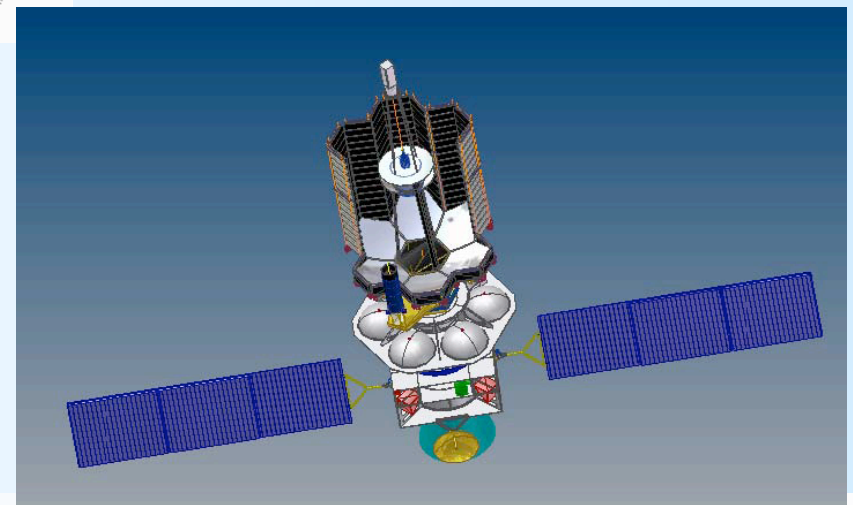
**SPOT Testbed**



**SPOT ISS  
Attached Payload  
or Free-flyer**



**30 meter-Class SPOT**



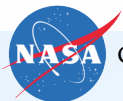
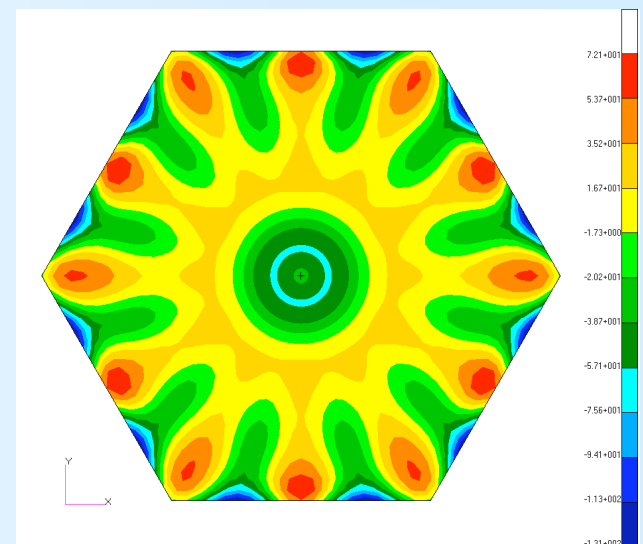
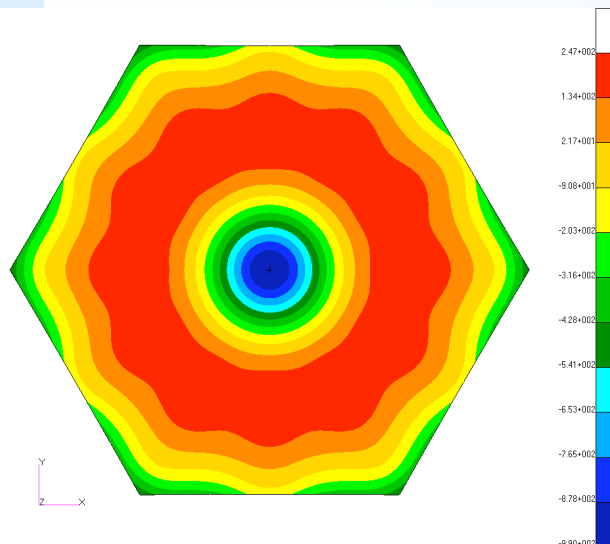
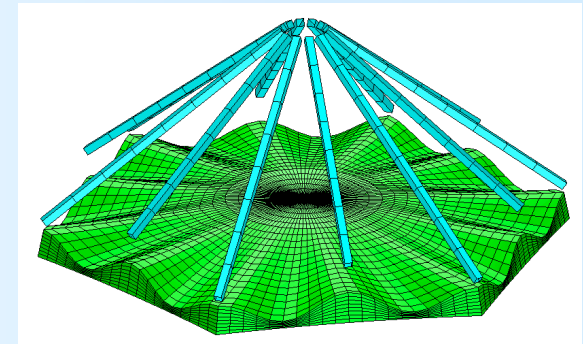


# Accomplishments

## SPOT Mirror Segment Design



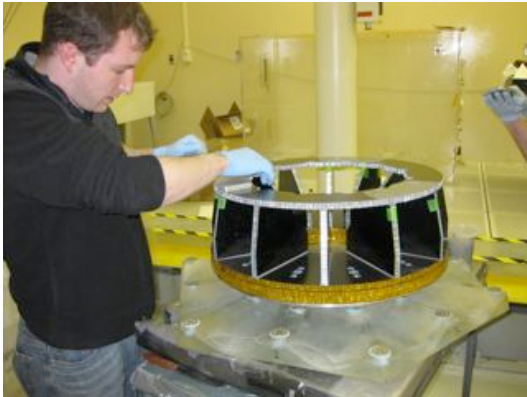
- **35" Mirror Blanks to be cast in pyrex for 15 X cost savings**
- **ROC control relaxes radius matching tolerance for significant fab cost savings**
- **Design optimized from initial to current profile**
- **ROC control induced WFE decreased from 225 to 32 nm**
- **Mirror profile minimizes thermal equilibration time**
- **Further optimization to 20 nm WFE over ROC control range possible**





# Accomplishments

## SPOT Segment 1 Pathfinder Assembly



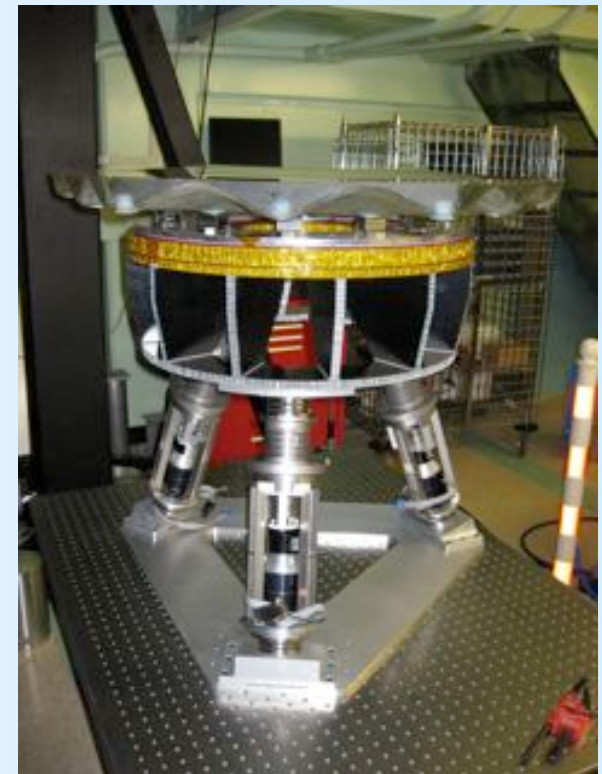
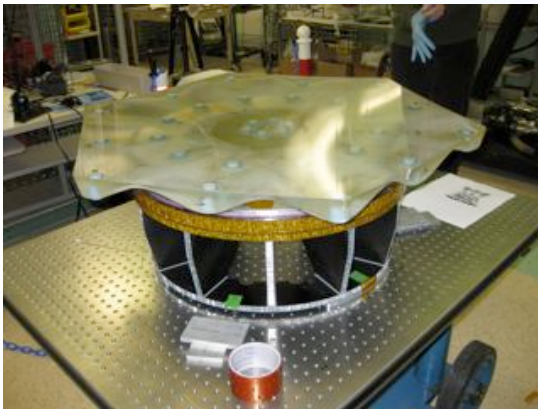
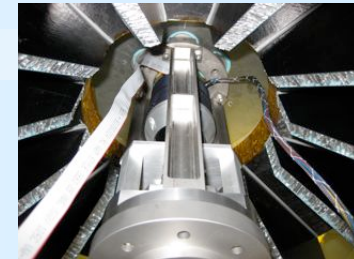
- **SPOT Mirror Composite Pathfinder Support Structure Assembled**

- **SPOT Segment 1 Figure Measured on Support Structure**

- **Segment 1 assembled to tip/tilt piston assembly and measured for MRF Hit Map for figuring**

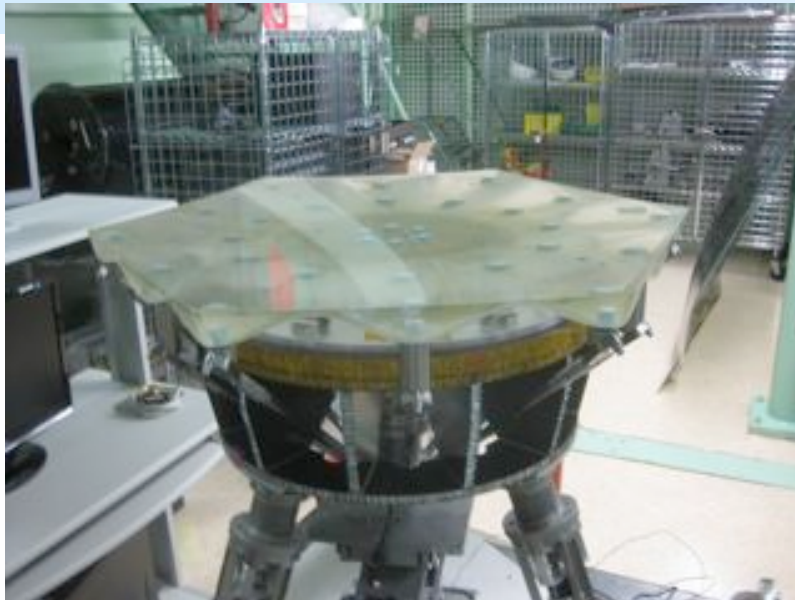
- **Check of figure change when Radius of Curvature Actuator integrated**

- **As predicted effect of 20 lb actuator assembly is primarily focus change**





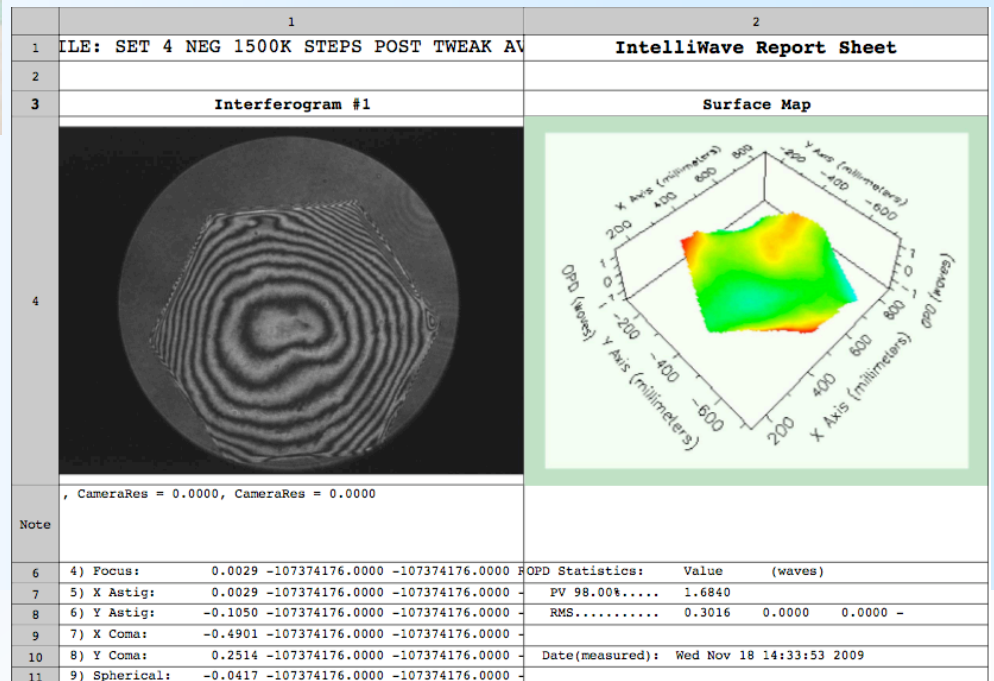
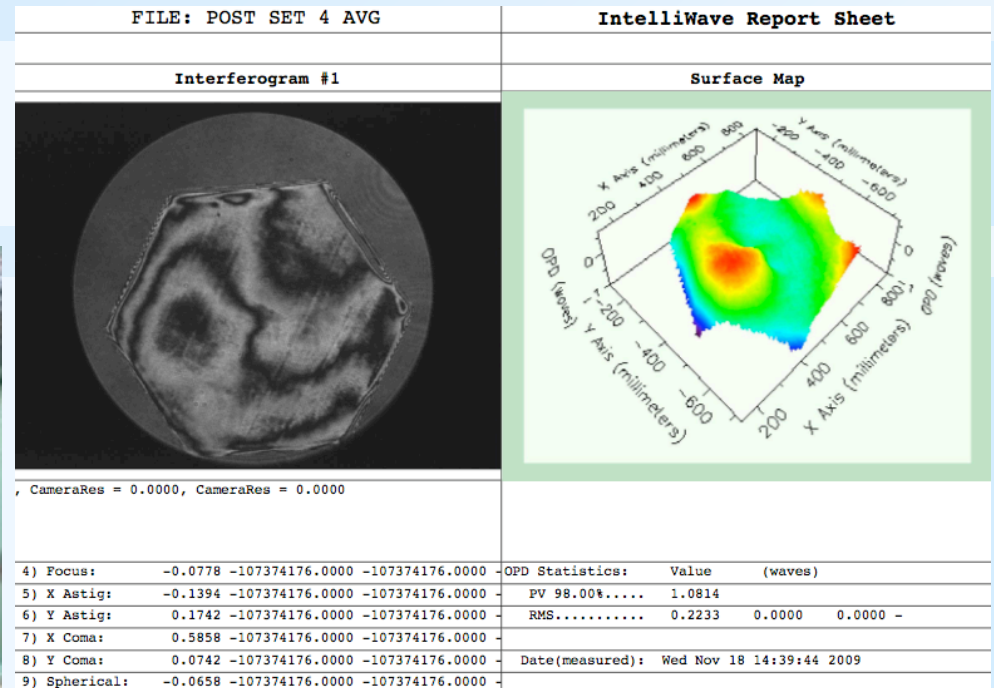
## SPOT Segment 1 ROC Adjustment



- SPOT Segment 1 radius adjusted by bending mirror
- This allows radius matching of segments in test bed
- Pathfinder segment had initial aberrations that limited performance



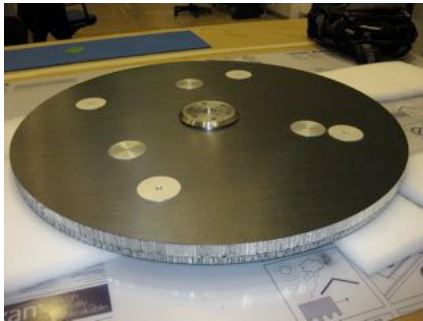
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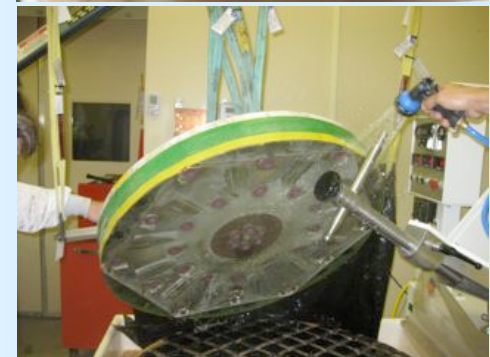


## Accomplishments - Meter Class Optics at GSFC

### Segment 2 Grinding and polishing



- **Bldg 7 Room 7 Reconfigured for Polishing Lab**
- **Composite Polishing Fixture fabricated ( $>10$  x lighter than previous fixture)**
- **Pitch pucks installed on polishing fixture**
- **Mirror polishing on new Strasbaugh 6-O machine**
- **Mirror being inspected**
- **Segment 2 surround removal**
- **4 Fabrication and Test related NTR's generated**



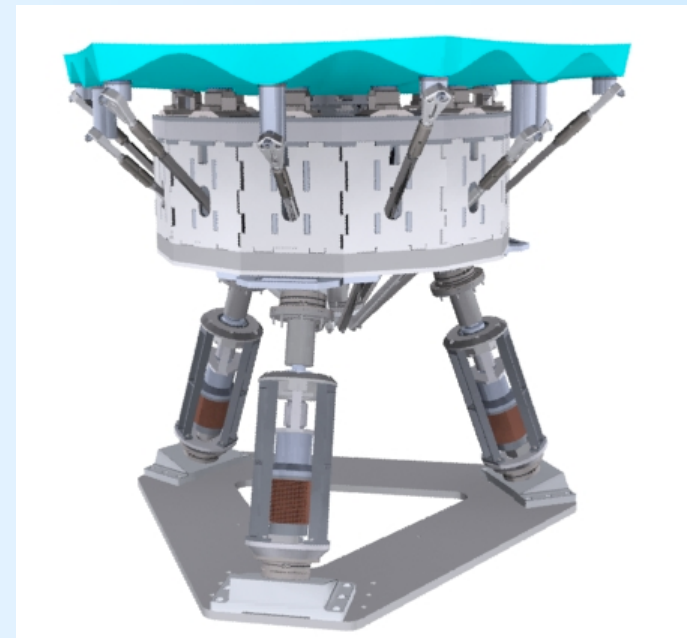


# Accomplishments

## Segment 2 Installed on Generation 2 Box



- **Fabricated in Composites Shop Bld 5**
- **Designed by J. Budinoff/540**
- **10-20x stiffer than Gen1**
- **Flexure interface**
- **Segment 2 Mounted**
- **Mirror fab 10x faster than Segment 1**
- **Mounted Figure 4 x better**
- **Next step final figuring at QED Technologies with MRF**





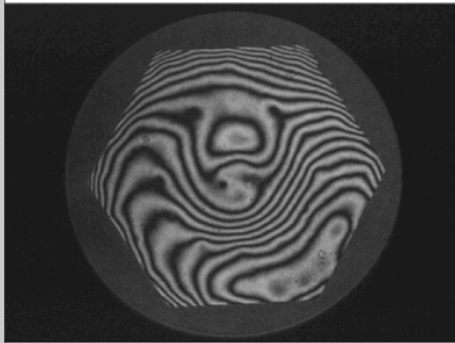
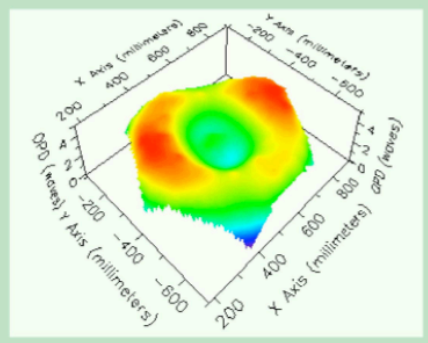
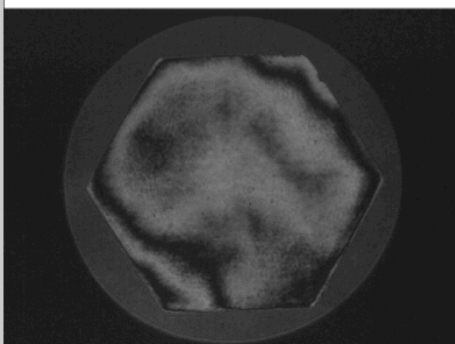
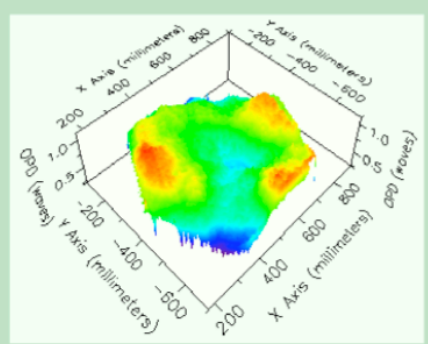
## SPOT Segment 2



- Better initial figure at GSFC
- Lower Mounting Error
- Optimized MRF Process at QED



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1				2			
FILE: 3_17				Segment 2 Pre MRF1			
				Wave Report Sheet			
Interferogram #1				Surface Map			
							
Note							
, CameraRes = 0.0000, CameraRes = 0.0000, CameraRes = 0.0000, CameraRes = 0.0000							
Date(measured): Thu Mar 18 17:20:21 2010				OPD Statistics: Value Min Max (waves)			
4) Focus: -0.7409 0.0000 0.0000 Removed				PV..... 4.9911			
5) X Astig: 0.9883 0.0000 0.0000 -				RMS..... 0.7546 0.0000 0.0000 -			
6) Y Astig: 0.8883 0.0000 0.0000 -							
7) X Coma: 0.3086 0.0000 0.0000 -							
8) Y Coma: 0.2403 0.0000 0.0000 -							
9) Spherical: -1.6143 0.0000 0.0000 -							
1				2			
: 5_27 SEG2 MRF2 F				Segment 2 Post MRF2			
				Wave Report Sheet			
Interferogram #1				Surface Map			
							
Note							
, CameraRes = 0.0000, CameraRes = 0.0000							
Date(measured): Thu May 27 13:57:40 2010				OPD Statistics: Value Min Max (waves)			
4) Focus: -0.0592 0.0000 0.0000 Removed				PV..... 1.2185			
5) X Astig: 0.0923 0.0000 0.0000 -				RMS..... 0.1372 0.0000 0.0000 -			
6) Y Astig: 0.1719 0.0000 0.0000 -							
7) X Coma: 0.0393 0.0000 0.0000 -							
8) Y Coma: 0.1290 0.0000 0.0000 -							
9) Spherical: -0.1414 0.0000 0.0000 -							



## Next Steps

- Segment 2 gets an additional 1 MRF at QED
- Segment 3 figuring at GSFC is within .05% of nominal radius (need to get to .025%)
  - Delivery to QED for at least 2 MRF runs
- Segments 1 and 2 will begin phasing experiments after delivery of Segment 2 from QED
  - Integration of tip/tilt piston control with WFSC module
  - Completion of WFSC module (WISH)
  - Completion of WFSC algorithms